SUBSTITUE SPECIFICATION

A Tunable Filter and Method of Tuning a Filter

Field of the Invention

The present invention relates to tunable filters, particularly but not exclusively to the tuning of the center frequency of a bandpass filter.

Background

A common problem in the design of bandpass filters is the need to tune the center frequency. Current component tolerances rarely provide the required accuracy, so some form of frequency tuning is inevitably required.

A paper presented at the 1999 IEEE International Solid-State Circuits Conference: "High-Frequency Analog Filters in Deep-Submicron CMOS Technology", R. Castello, I. Bietti, F. Svelto, ISBN 0-7803-5126-6/99, describes an LC based filter using a master-slave frequency tuning scheme. This scheme uses the same reactive elements, in this case, MOS varactors, in a bandpass filter acting as slave and a voltage controlled oscillator (VCO) acting as master. The center frequency of the filter is controlled by the same signal as the oscillator, so that when the oscillator is operating at a desired frequency, that frequency becomes the center frequency of the filter.

The master-slave technique relies on matching two different structures, namely the filter and the VCO, which can only be done to an accuracy of 1 – 2 per cent. Furthermore, the technique involves substantial additional chip area and power consumption.

The present invention aims to address the above problems.

Summary of the Invention

According to the invention, there is provided a method of tuning a filter, the filter being associated with a center frequency, comprising the steps of configuring said

filter as an oscillator, tuning said oscillator to a desired frequency and reconfiguring said oscillator to operate as said filter with said desired frequency as said center frequency.

By converting the filter itself into an oscillator and tuning the oscillator, few additional components are required, so saving on chip area and power consumption. Furthermore, by comparison with solutions in which the operational filter is matched to a second similar filter or oscillator using the same reactive components, the inherent limitations resulting from the matching of similar but non-identical structures is removed.

According to the invention, there is further provided a tunable filter, comprising a filter circuit having a center frequency and a configuration circuit operable to configure said filter circuit as an oscillator, whereby to permit said oscillator to be tuned to a desired frequency, said configuration circuit further being operable to reconfigure said oscillator to operate as said filter with said desired frequency as said center frequency.

The invention also provides a tunable filter, comprising a filter circuit having a center frequency and means for configuring said filter circuit as an oscillator, whereby to permit said oscillator to be tuned to a desired frequency, said means further being operable to reconfigure said oscillator to operate as said filter with said desired frequency as said center frequency.

The filter can be a bandpass filter or a notch filter.

The invention additionally provides a method of tuning a filter, said filter comprising reactive components which determine a resonant frequency of the filter, said method comprising the steps of configuring the filter as an oscillator and tuning at least one of said reactive components while the filter is configured as said oscillator.

According to the invention, there is yet further provided a programmable filter comprising a filter circuit, a compensation circuit and a memory for storing at least one digital word, wherein the compensation circuit is operable to configure said filter circuit as an oscillator, whereby to permit said oscillator to be tuned to at least one desired frequency in accordance with a tuning signal, said tuning signal being derived from said at least one digital word, said compensation circuit further being operable to reconfigure said oscillator to operate as said filter after tuning.

By storing a plurality of digital words in the memory, each representing a different center frequency for a bandpass filter, the filter can be quickly programmed to operate at different frequencies depending on operational requirements.

Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates a conventional LC tank circuit comprising a capacitor and an inductor in parallel;

Figure 2 shows the equivalent circuit diagram for the LC tank of Figure 1a, illustrating the presence of a parasitic resistance;

Figure 3 illustrates an equivalent circuit in which the parasitic resistance is compensated for by a negative resistance;

Figure 4 shows an example of a negative resistance circuit;

Figure 5 illustrates the frequency response of a bandpass filter;

Figure 6 illustrates a tunable filter circuit according to an example of the invention;

Figure 7 is a flow diagram illustrating the operation of the circuit of Figure 6;

Figure 8a illustrates a tank circuit in which a variable capacitor acts as the frequency tuning element;

Figure 8b illustrates a MOS varactor for implementing the variable capacitor of Figure 8a;

Figure 8c illustrates a diode varactor for implementing the variable capacitor of Figure 8a;

Figure 8d illustrates a Miller capacitance arrangement for implementing the variable capacitor of Figure 8a;